

Inquiry and Investigation Lesson Plan

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Course Name : Earth Systems

STANDARD IV: Students will understand that water cycles through and between reservoirs in the hydrosphere and affects the other spheres of the Earth system.

Objective 1: Explain the water cycle in terms of its reservoirs, the movement between reservoirs, and the energy to move water. Evaluate the importance of freshwater to the biosphere.

Intended Learning Outcomes (ILOs) Fulfilled

- 1h Construct models, simulations and metaphors to describe and explain natural phenomena.
- 2d Accept responsibility for actively helping to resolve social, ethical and ecological problems related to science and technology.
- 3a Know and explain science information specified for the subject being studied.
 - b. Distinguish between examples and non-examples of concepts that have been taught.
 - c. Apply principles and concepts of science to explain various phenomena.
 - d. Solve problems by applying science principles and procedures.
- 5a Cite examples of how science affects human life.

Time Needed To Complete Inquiry: 50-70 minutes

Inquiry: What is the research question? How do scientists locate pollution sources to ground water? I will use Guided Inquiry to create a model students can test.

Assessment: How will you know that your students have met the objective? Students will find the source of pollution. Are there application extensions to this activity, interpretative test items, etc.? Extension: Aquifer Activity

Prior Knowledge Needed: What background knowledge and skills do the students need to be prepared for this inquiry? How will they obtain it? Students will read and discuss a news article about a chemical spill.

Introduction: Tell how you will introduce the inquiry to your students to make it meaningful and relevant. A glass of water will be polluted with a clear colorless chemical (HCl). Student will discuss how important safe clean water is to them.

Materials / Resources Needed for the Investigation: see below

Procedures of the Investigation: Describe the actual investigation. What will the students do? If applicable, identify the independent and dependent variables, the constants, and the repeated trials. See below

Data Collection: How will students collect and organize data (tabulation)?

Data Analysis: How will students be able to interpret the data (e.g., graphs), to reach consensus (if appropriate)? How will they draw conclusions? See below

Closure: How will you provide closure to the experience? How will students effectively communicate what they learned? See below.

Earth Systems

Standard 4: Objective 1

Title: Midnight Dumpers

Brief Description: Will sample “wells” to try and find the source of groundwater contamination

Objective: Students should gain a greater understanding of how and why chemical dumping occurs. They will also better understand how pollution spreads through underground reservoirs.

Materials needed: Student sheets, master-copy of maps, 20 medicine jars or film canisters (amber color or dark but not transparent) , 600 popcorn seeds, food coloring, lid from a cardboard box, optional: candy bar prizes

Background Knowledge: Students should understand that water from rain and other sources sinks into the ground and is widely used for by humans for drinking and household use. Contaminants placed on the soil will sink in and pollute the groundwater. The contaminants will also “drift” as the groundwater moves or the contaminant spreads.

Time needed: 50 minutes

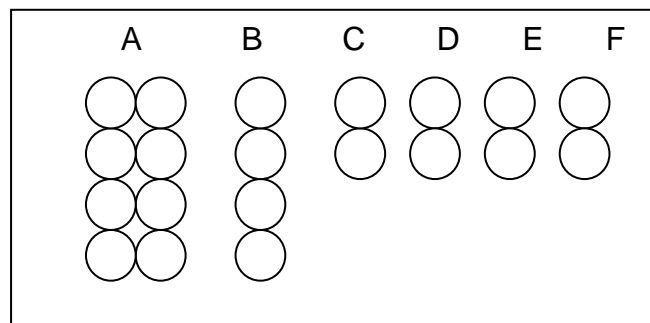
Safety/Security Concerns: None

Teacher procedures:

1. Make copies of the student sheets. Make an overhead copy of the city map.
2. Print off the map and teacher map key. This is a sample map. You should make enough map keys for each class you will do the activity with. It is important that in each class the dumping occurs in a different location, because news travels in a school. There are three versions of the activity available. Run off a classroom set of each student map and a teacher map for each version. On the teacher map, fill in the letters of each location going from F to A as the spill dilutes. E, should be close to the site and the letters move towards A as the location gets further from the contamination site. Be sure students do not see the keys during this activity.
4. Label and assemble the medicine jars with seeds in them according to the chart below. The medicine jars should be labeled by writing the letter on the bottom with permanent marker. The seeds should be dyed by soaking them in green food coloring overnight and drying them.

Medicine Jar Label	Number of Jars	Number of Yellow Seeds	Number of Green Seeds
A	8	18	2
B	4	15	5
C	2	12	8
D	2	9	11
E	2	6	14
F	2	3	17

5. Organize the jars according to letter on the lid of a cardboard box, as shown. Keeping the jars organized throughout the class period will make this activity run much more smoothly. As students return a jar to you, be sure to replace it in its designated area. You might also want to keep this hidden under your desk so your especially perceptive students don't catch on to the method.



- Put the city map on the overhead so it is visible as students arrive into the classroom.
- Hook:** Ask the students to read one of the newspaper articles available on this website. Ask a student to summarize each article. Have a cup of water in a clear glass. Ask the students if it is clean and how they know that. You could stir salt in it and dissolve it and then ask the same questions.
- Pass out student sheets. Have students read the "Background Information" through the "Prediction."
- Discuss the lab (especially the **background information**) with the students and answer any questions they might have. You may want to offer a prize to the team that correctly identifies the well with the most profit, or in the case of some classes, the least loss.
- Demonstrate for students how to sample a well and do the calculation.
- As students request wells, use your key to know which letter well (jar) they will receive. Don't let students have more than one sample at a time. They must exchange one sample for another.
- Discuss the results of this activity with students when everyone has located the site.

Sample Scoring Guide:

Requirement	Points Possible
Purpose/Prediction Questions	4
Data Table Complete	10
Analysis Questions answered correctly	20
Conclusions valid and complete	8
Ended with profit	3
Total	45

Sample Answers:

- 1. Answers will vary, answers will vary.*
- 2. Answers will vary, the pollution followed the flow of the water. There was no pollution directly upstream of the contamination site.*
- 3. Answers will vary.*
- 4. It is important so that authorities can stop the polluting, find the guilty parties, and clean up the contamination.*
- 5. Midnight dumping occurs because it is a cheap way to get rid of waste. It is expensive for businesses to comply with all of the EPA and state laws on how to correctly treat and dispose of their waste.*
- 6. Once pollution is on the ground it seeps through the pore spaces in the soil and into the aquifer or groundwater supply.*
- 7. The more porous the soil the more quickly the pollution will spread. If the soil is very nonporous like clay, the consequences of dumping would not be as immediate.*
- 8. As water is pumped out of a well it pulls the surrounding ground water towards it. This draws or attracts the pollution.*
- 9. It is a good idea to test more than once so you get an accurate perspective of what the water is truly like inside the well. It was luck which seed you pulled out, you may have pulled out the same polluted seed 3 times, giving you a distorted picture of how polluted the water really was.*
- 10. If you see illegal chemical dumping it is best to contact the local law enforcement.*

Answers to Conclusions:

Answers will vary but should be detailed, relevant and in complete sentences.

Name: _____

Period: _____

Title: Midnight Dumpers

Background Information:

Groundwater acts as a very important reservoir for water in the hydrosphere. In Utah much of our drinking water comes from underground reservoirs. As water cycles through the hydrosphere it is naturally cleansed from its impurities. This happens in two ways: through evaporation and through filtration underground. These natural processes are vital to maintaining a clean water supply.

Water is sometimes polluted as it travels through the ground. This happens because of chemical dumping, both legal and illegal. Some industries produce large amounts of waste as byproducts of their manufacturing. The Environmental Protection Agency (EPA), in cooperation with local and state governments sets limits and rules for how much waste can enter the environment and how it can be distributed. Many of these processes required by EPA are costly and time consuming for companies. This has led to an illegal practice known as “midnight dumping.” In this practice wastes are illegally dumped, sometimes far from the place they were made.

The consequences of this type of dumping are far-reaching. This is because the waste is not only harmful where it is dumped, but it often seeps into the ground, moving through the pore spaces in the soil and contaminating the underground aquifer. The pollution then spreads as it travels with the flow of the underground reservoir. Excessive fertilizers and pesticides on your lawn can also pollute the aquifer. You should never dump anything on your lawn or down your drain that you wouldn't want to drink.

Purpose:

This lab simulates the effects of midnight dumping. In this case you are a firm hired by the city to find the source of illegal dumping. You must drill wells and sample the water in each well. The cleanliness, or lack thereof, of the water is represented by the color of popcorn seeds. A green seed is polluted water and a yellow seed represents clean water. The more green seeds in a well the more polluted that water is. How will you know your team is getting closer to the source of contamination?

Materials: Map, medicine bottles with 20 seeds in them

Procedures:

1. Look at the map and find 3 small dots. The darkest is a routine well sample that shows some pollution is present. The lighter colored dot shows a smaller amount of pollution and the white dot shows a clean sample.
2. Decide on the coordinates you want to “test” first.
3. Send a person up to get a test sample of “ground water” from your teacher. You may only test one well at a time.

4. Sample each by dumping the seeds and counting the green and yellow. Calculate a percentage by dividing the total number (20) into the number of green seeds and multiplying by 100%.
5. Each well drilled will cost you \$1,000. You will be paid \$10,000 for your work. Keep track of your costs.
6. Quit when you think you have the spot located. You will be charged \$2,000 for an incorrect guess. So be very certain before you guess. Keep the site private from competing teams.

Predictions: Where (description of the site and the coordinates) do you think the contamination occurred and why.

Data:

Location	Number of Yellow Seeds	Number of Green Seeds	% pollutant	Total Cost for this Location	Total Costs Accrued

Analysis:

1. What site did you identify? How many spaces off were you?

2. What direction was the water flowing underground? How did you know this?
3. You started with \$10,000. Subtract your total costs to find your profit or loss.
4. Why is it important to identify the correct spot?
5. Why does “midnight dumping” occur?
6. Where does pollution go that is dumped on the soil?
7. How could the type of soil influence the spread of pollution?
8. How does a well “attract” pollution?
9. Why is it a good idea to do more than one test on a well? What role did luck play in this lab?
10. What should you do if you see someone illegally dumping or spilling chemicals?

Conclusions: In complete sentences explain 2 concepts that you learned by completing this activity.